इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

“जानने का अधिकार, जीने का अधिकार”
Mazdoor Kisan Shakti Sangathan
“The Right to Information, The Right to Live”

“पुराने को छोड नये के तरफ”
Jawaharlal Nehru
“Step Out From the Old to the New”

IS 10215 (1982): Methods of tests for submerged arc furnaces [ETD 17: Industrial Electroheating Equipment]

“ज्ञान से एक नये भारत का निर्माण”
Satyanarayan Gangaram Pitroda
“Invent a New India Using Knowledge”

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

Made Available By
Public.Resource.Org

“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”
Bhartṛhari—Nītiśatakam
“Knowledge is such a treasure which cannot be stolen”

BLANK PAGE

BRUTUM FULMEN
IGNORANTIA JURIS NON EXCUSAT
PROTECTED BY COPYRIGHT

IS : 10215 - 1982

(Reaffirmed 2001)

Indian Standard

METHODS OF TESTS FOR SUBMERGED-ARC FURNACES

UDC 621·365·2 : 620·16

© *Copyright* 1982

INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 3 *November* 1982

Indian Standard

METHODS OF TESTS FOR SUBMERGED-ARC FURNACES

Industrial Electro-heating Equipment Sectional Committee, ETDC 61

Chairman	*Representing*
Shri S. K. Mazumder	Tata Iron and Steel Co Ltd, Jamshedpur
Members	
Shri A. K. Biswas (*Alternate* to Shri S. K. Mazumder)	
Shri G. A. Advani	Westerwork Projects Ltd, Bombay
Shri L. C. Chandi (*Alternate*)	
Shri S. N. Agarwal	Steel Furnace Association of India, New Delhi
Shri S. K. Bhattacharji	M. N. Dastur & Company (P) Ltd, Calcutta
Shri T. K. Ghosh (*Alternate*)	
Shri R. M. Chandwani	Hindustan Brown Boveri Ltd, Vadodara
Shri P. S. Sharma (*Alternate*)	
Shri Kaushal Goel	Engineering Projects (India) Ltd, New Delhi
Shri M. M. Prasad (*Alternate*)	
Shri S. S. Hubli	Kirloskar Electric Co Pvt Ltd (Unit IV), Mysore
Shri S. S. Hemachander (*Alternate*)	
Shri A. K. Jain	Graphite India Ltd, Calcutta
Shri J. K. Agarwal (*Alternate*)	
Shri G. L. Keswani	Directorate General of Technical Development, New Delhi
Shri A. K. Kesavalu (*Alternate*)	
Shri S. V. Krishna Rao	Bharat Heavy Electricals Ltd, Secunderabad
Shri B. Pathiraj (*Alternate*)	
Shri O. N. Krishnan	Metallurgical & Engineering Consultants (India) Ltd, Ranchi
Shri J. C. Madan	Steel Authority of India Ltd, New Delhi
Shri A. K. Jain (*Alternate*)	
Shri P. K. Mukhopadhyay	Heavy Machine Building Plant, Heavy Engineering Corporation, Ranchi
Shri M. K. Nair	Directorate General of Ordnance Factories (Ministry of Defence), Calcutta
Shri P. A. Patel	Indian Furnace Co Ltd, Bombay
Shri M. Purandhar (*Alternate*)	
Shri V. R. K. N. Sastri	Mishra Dhatu Nigam Ltd, Hyderabad
Shri N. Raghavan (*Alternate*)	

(*Continued on page* 2)

© *Copyright* 1982

INDIAN STANDARDS INSTITUTION

This publication is protected under the *Indian Copyright Act* (XIV of 1957) and reproduction in whole or in part by any means except with written permission of the publisher shall be deemed to be an infringement of copyright under the said Act.

(*Continued from page* 1)

Members	*Representing*
Shri M. Shankralingam	Directorate General of Supplies & Disposals, New Delhi
Shri R. V. Narayanan (*Alternate*)	
Shri Y. P. Vatsa	The General Electric Co of India Ltd, Calcutta
Shri S. M. Banerjee (*Alternate*)	
Shri S. P. Sachdev, Director (Elec tech)	Director General, ISI (*Ex-officio Member*)

Secretary
Shri Jose Mathew
Assistant Director (Elec tech), ISI

Indian Standard

METHODS OF TESTS FOR SUBMERGED-ARC FURNACES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 5 May 1982, after the draft finalized by the Industrial Electroheating Equipment Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard covers the methods of tests for submerged-arc furnaces to determine their main parameters and technical characteristics.

0.3 In preparing this standard, considerable assistance has been derived from IEC 683-1980 ' Test methods for submerged-arc furnaces ' issued by International Electrotechnical Commission.

0.4 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard specifies the test methods for industrial three-phase submerged-arc furnaces with rated power levels of 1 000 kVA or more.

1.2 This standard also applies, where appropriate, to furnaces having one or more electrodes, other than three-phase furnaces.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Submerged-Arc Furnace (Arc-Resistance Furnace) — Arc furnace in which the electrode or electrodes are positioned in the charge. A significant part of the heat is generated by resistance of the charge.

---

*Rules for rounding off numerical values (*revised*).

2.2 Furnace Accessories — Furnace assembly with complete set of electrical equipment including high-voltage equipment, furnace transformers, secondary voltage busbar system, tapping electrode with tapping busbar, equipment for reactive power compensation and/or voltage stabilization (if supplied), automatic power regulator and also boards, panels and desks with protection, control measuring and signalling devices.

2.3 Furnace Body — Steel shall of which the bottom and the side walls have a refractory lining, and intended to receive the charge. The furnace may be of either open or closed type.

2.4 Furnace High-Voltage Switch — High-voltage switch which serves for switching on and off the furnace transformers under load in accordance with operating requirements.

2.5 Furnace Transformers — The transformers feeding the arc furnace from the high-voltage network and providing a voltage range suitable for the furnace operation.

2.6 Rated Power of Furnace Transformers — Maximum admissible continuous power of furnace transformers (without time limitation) at the specified secondary voltage tapping.

2.7 Electrode of Submerged-Arc Furnace — Current carrying column, generally of the continuous self-baking type, which ensures the passage of the current through the arc and the charge to another electrode and/or to the liquid bath. The continuous electrode for the arc furnace consists principally of an envelope usually of metal filled with a plastic carbon compound baked by the electrode current and the furnace heat.

2.8 Main Electrical Circuit of the Arc Furnace Installation — That part of the arc furnace installation, which includes the high-voltage equipment, reactor (when used), furnace transformers, heavy current line, arc and charge.

2.9 Electrode Clamp — A device for clamping the electrode in a given position, and for supplying current to the electrode.

2.10 Heavy Current Line (Low-Voltage) — Assembly of series connected elements of the secondary circuit comprising; electrodes and secondary voltage busbar system (electrode clamps, busbar system of electrode arms, flexible cables and transformer secondary busbar connection) intended to carry the required electrical power from the transformers to the charge material contained in the furnace body.

2.11 Asymmetry Factor on Primary Side — Percentage ratio of the difference between the maximum and minimum phase impedance, including the furnace transformers, to the mean impedance of all the phases of the arc furnace installation :

$$K_{as} = \frac{Z_{max} - Z_{min}}{Z_{mean}} \times 100 \text{ percent} \qquad \dots (1)$$

where

Z_{max} = maximum phase impedance of arc furnace installation,

Z_{min} = minimum phase impedance of arc furnace installation, and

Z_{mean} = arithmetic mean value of all phase impedances.

Calculated asymmetry factor is determined for the furnace current corresponding to the rated power of the furnace transformers (*see* **3.7**).

The asymmetry factor is determined for the furnace current at given voltage value.

2.12 Active Power of Furnance Installation (kW) — Total active power of the three phases of arc furnace installation.

Note 1 — Instantaneous value of active power of the furnace may be measured at any moment, simultaneously on the three phases.

Note 2 — Mean value of active power of the furnace within a definite time interval may be obtained as a result of division of consumed electrical energy measured in kWh by the duration of the time it is switched on, measured in hours.

2.13 Specific Electrical Energy Consumption (kWh/t) — Quantity of electrical energy measured in kWh consumed by an arc furnace installation for the processing of one tonne of final product.

2.14 Power Factor of Furnace Installation (cos ϕ) — The approximate value of the power factor is determined from the following formula:

$$\cos \phi = \frac{P}{\sqrt{P^2 + Q^2}} \qquad \dots (2)$$

where

P = active power, and

Q = reactive power.

Note 1 — Because of the possible presence of harmonics, the measurement of the power factor is not necessarily correct.

NOTE 2 — The instantaneous value of the furnace installation power factor may be obtained by simultaneously measuring the active and reactive power at any moment.

NOTE 3 — The value of the average power factor of furnace installation over a definite period of time, may be obtained from the following :

$$\cos \phi = \frac{E_P}{\sqrt{E_P^2 + E_Q^2}}$$

where

E_P = active electrical energy measured for a definite period of time, and

E_Q = reactive electrical energy measured for the same period of time.

2.15 Cooling Water Consumption — Water used for cooling of an arc furnace installation measured in m^3/h.

The total cooling water consumption is usually subdivided as follows:

a) Consumption for the furnace proper, including secondary voltage busbar system and cables where water cooling is used;

b) Consumption to cool the furnace transformer;

c) Consumption to cool the other equipment, belonging to the furnace installation, including fume extraction; and

d) Consumption of other system, if any, for example, cleaning system.

2.16 Cold State of Submerged Arc Furnace Installation — State of furnace and its installation when the temperature of all its parts equals the ambient temperature.

2.17 Hot State of Furnace — Thermal state of furnace defined after 48 hours of nornal and continuous operation.

3. TESTS

3.0 General Conditions for Performing Test — The general conditions for performing the tests shall be in accordance with IS : 9021-1978*.

---

*General test conditions for industrial electroheating equipment.

3.0.1 The furnace shall be prepared for tests and put into operation at the purchaser's site in accordance with the service instructions and the requirements for safeworking.

3.0.2 The mains supplying the furnace installation during tests shall ensure a symmetry of voltage between separate phases. No interruption of power supply shall occur during tests or during an adequate time before.

3.0.3 The mains supply voltage level at the transformer primary shall be within ± 5 percent. Voltage levels outside these limits may be admitted in tests by agreement between the manufacturer and the user. In any case the test results shall be converted to the reference rated voltage value.

3.1 List of Tests — The following tests shall be carried out to check the operating conditions of the submerged-arc furnace :

a) Measurement of electrical insulation of the heavy current line (secondary voltage) (*see* **3.2**),

b) Measurement of cooling water consumption (*see* **3.3**),

c) Determination of the electrode motion regulating system characteristics (*see* **3.4**),

d) Determination of furnace electrode baking temperature along the length of electrode column (*see* **3.5**),

e) Determination of the electrical characteristics during operation (*see* **3.6**),

f) Determination of the asymmetry factor on primary side (*see* **3.7**), and

g) Determination of the other main operating characteristics (*see* **3.8**).

NOTE — It is recommended that the tests specified in (a) to (c) should be carried out on every newly installed or reconstructed furnace. The tests in (d) to (g) need not be carried out if the corresponding data are given in the technical documentation of the submerged-arc furnace and if they are guaranteed by the furnace manufacturer; but these tests shall be carried out if the technical data differ from the actual data obtained during the furnace operation.

3.2 Measurement of Electrical Insulation of the Heavy Current Line — Two tests shall be carried out on the de-energized furnace with the electrodes completely mounted and in the following order:

a) In cold state, on complete installation of an empty furnace without water circulation; and

b) In hot state, on a complete furnace installation with water circulation.

3.2.1 *Measurement of Electrical Insulation of Heavy Current Line of the Furnace in Cold State* — The testing of the furnace in the cold state shall be carried out by means of a 1 000 V dc megohm-meter.

In the tests on the furnace installation, the measurement of the insulation shall be carried out between all the three electrically connected phases and the earthed metal body of the furnace.

3.2.2 *Measurement of Approximate Electrical Insulation of the Heavy Current Line in Hot State* — Under consideration.

3.3 Measurement of Cooling-Water Consumption — The purpose of this test is to check the cooling water consumption as foreseen by the manufacturer during normal operation.

The test shall be carried out when the furnace is in the hot state. The pressure, temperature and properties of the cooling water shall correspond to the requirements given in the technical documentation by the furnace manufacturer. The temperature of outlet water should be measured at every 15 minutes by means of a thermometer scaled from 0 to 100°C.

The cooling water consumption is determined from the following formula :

$$q = \frac{Q}{t} \qquad \ldots(3)$$

where

Q = quantity of water measured in m^3, and

t = period of time during which the quantity of water flows through a separate cooling branch in hours.

During the test, it is desirable to determine the cooling water properties (hardness, quantity of suspended particles, etc) and compare these with the manufacturer's recommendations.

3.4 Determination of the Electrode Motion Regulating System Characteristics

3.4.1 *Measurement of Speed of the Electrode Motion* — The measurement is made with manual control of the driving power for movement of the electrode in two directions. The measurement of the speed of motion is carried out separately on each electrode and then on all three electrodes together by means of a stop watch noting the distance covered by the electrode relative to its fixed support. The measurement should be carried out before the raw materials are charged.

3.4.2 *Determination of Dead Band of Electrode Regulators* — During normal operation the insensitivity of the regulators should be adjusted to suit the furnace operating conditions.

3.4.3 *Determination of Total Response Time of the Electrode Motion Regulating System* — Under consideration.

3.5 Determination of Furnace Electrode Baking Temperature Along the Length of Electrode Column — Under consideration.

3.6 Determination of the Electrical Characteristics During Operation — To determine the values of the impedance Z, resistance R, and reactance X of the heavy current line and asymmetry factor on the primary side, the measurements are performed on the primary side of the transformers and the results converted to give the required values.

In the case of submerged-arc furnaces, the short-circuit test is much more difficult to perform than in the case of direct-arc furnaces. Therefore this shall be a matter for agreement between the manufacturer and the user. The determination shall be made with the electrodes in normal operating position with the required voltage for each current level obtained from the following tests:

The first test shall be conducted at an operating value equalling half of the rated current value, the second test at an operating value equalling three-fourths of the rated current value and the third test at an operating value equal to the rated current value.

If it is possible to carry out these three tests, the characteristic values, namely, the impedance, the resistance and the reactance can be determined by drawing a simplified circle diagram as shown in Fig. 1.

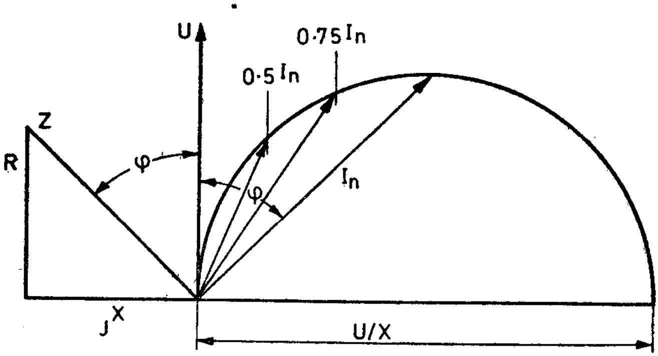
If it is possible to carry out the short-circuit test, the full circle diagram as shown in Fig. 2, can be obtained.

The reactance determined from a short-circuit test is representative of abnormal operating condition.

NOTE — For submerged arc furnaces it is the resistance in normal operation with the normal position of electrodes which is important.

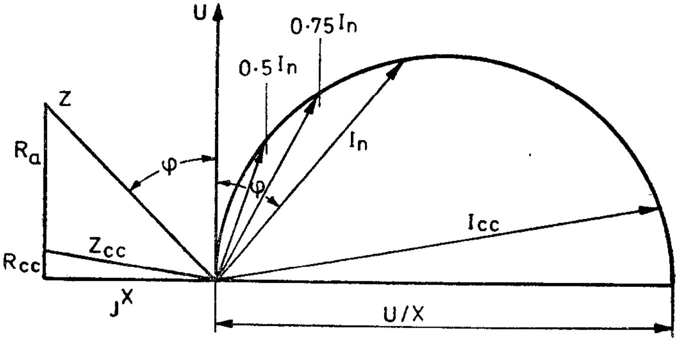
3.7 Determination of the Asymmetry Factor on Primary Side — Determination of the asymmetry factor of a submerged-arc furnace shall be made, as far as possible and in the case of a prior agreement between the manufacturer and the user, on the basis of the value of phase impedances from the formula given in **2.11**.

The arithmetic mean value of the assymetry factor from two or more measurements shall be adopted as the test result.



Z = Impedance
R = Resistance, and
X = Reactance

FIG. 1 SIMPLIFIED CIRCLE DIAGRAM OF THE OPERATION OF AN ARC-RESISTANCE FURNACE



R_a = Arc and Charge Resistance
R_{cc} = Short Circuit Resistance, and
Z_{cc} = Short Circuit Impedance

FIG. 2 CIRCLE DIAGRAM OF THE OPERATION OF AN ARC-RESISTANCE FURNACE SHORT CIRCUIT TEST

3.8 Determination of the Other Main Operating Characteristics

3.8.1 *General* — The measurement of operating characteristics shall comprise the following :

a) Specific electrical energy consumption,

b) Mean power factor for a considered period of time, and

c) Specific electrode wear.

3.8.2 *Test Conditions* — Two tests shall be carried out, each over a period of time sufficient to give an accurate result.

In the case of continuous tapping, the time between two successive tappings shall be reckoned. A procedure shall be adopted, so that a complete tapping shall be terminated after 24 hours.

In the case of intermittent tapping the period between one tapping and another shall be agreed upon between the manufacturer and the user.

In the event of electrode breaking the test shall be repeated.

The following quantities shall be determined:

a) *Specific electrical energy consumption during the considered period*

This is derived from formula :

$$e_P = \frac{E_{Pt} - E_{PO}}{G} \qquad \ldots (4)$$

where

E_{Pt} = reading of the active energy meter after the considered period is completed in kWh;

E_{PO} = reading of the active energy meter at the moment the considered period was started in kWh; and

G = mass of tapped product in tonnes.

NOTE — By agreement between the manufacturer and the user the specific electrical energy consumption may be referred to the quantity of raw materials.

b) *Mean power factor for the considered period*

This is derived from formula:

$$\cos \phi = \frac{E_{Pt} - E_{P0}}{\sqrt{(E_{Pt} - E_{P0})^2 + (E_{Qt} - E_{Q0})^2}} \qquad \ldots (5)$$

where

E_{Qt} = reading of the reactive energy meter after the considered period is completed (KVARH), and

E_{Q0} = reading of the reactive energy meter at the moment the considered period was started (KVARH).

The measurement of active and reactive electrical energies shall be made by means of a suitable and verified three-phase meter installed on the high-voltage side.

c) *Specific electrode wear*

The measurement of the specific electrode wear shall be carried out over a period of at least three days. Electrode or electrode paste of a specified kind, agreed upon between the manufacturer and the user, shall be employed.

The electrode wear is determined by the mass (kg) of the eletrodes consumed over a period time, sufficient to give an accurate result.

The specific electrode wear q is determined as the quotient of electrode wear Q expressed in kg and the total mass of tapped product G expressed in tonnes:

$$q = \frac{Q}{G} \qquad \ldots (6)$$

3.8.3 *Test Results* — The values to be recorded for the different test parameters, for instance:

$e_{P_{mean}}$, mean power factor and q_{mean}

shall be determined as the arithmetic mean of the different values recorded for each parameter during the two or more tests made.